Tourist Evacuation Guidance Support System for Use in Disasters

Toshiki Sato, Tomoko Izumi, and Yoshio Nakatani

Graduate School of Science and Engineering, Ritsumeikan University,
Kusatsu, Shiga, 525-8577 Japan
is0019ev@ed.ritsumei.ac.jp,
{izumi-t,nakatani}@is.ritsumei.ac.jp
http://www.sc.ics.ritsumei.ac.jp/

Abstract. Japan is a country that is affected by many disasters such as earthquakes, volcanic eruptions, and typhoons. The Japanese populace fears the occurrence of a major earthquake, such as an earthquake caused by the Nankai Trough and an earthquake in the Tokyo metropolitan region, which are expected to occur with a high probability within 30 years. For these reasons, seismic countermeasures have attracted considerable attention from Japanese people, and the Japanese government is taking various measures against earthquakes. Accordingly, this paper proposes a disaster information provision system using Wi-Fi access points, which gives evacuees disaster information and evacuation routes based on the user's location. We assume users of our system to be tourists, both domestic and from overseas. This system has two main functions, the first of which is to provide tourists with information about the disaster, public transportation, and evacuation areas. By using our system, it is anticipated that smooth evacuation can be realized at an early stage. In addition, as the second main function, our system aims to prevent the concentration of evacuees at the main transport terminal by guiding them to each evacuation space.

Keywords: Disaster information, evacuation support system, tourist, bus stop.

1 Introduction

Japan is known worldwide as a country prone to natural disasters, including earthquakes, volcanic eruptions, and typhoons. In particular, major earthquakes, such a Tokai Earthquake, a Tonankai Earthquake, or a Nankai earthquake caused by the Nankai Trough and an earthquake in the Tokyo metropolitan region are predicted to occur within the next 30 years. As a result, focus on seismic countermeasures in Japan is growing, and the Japanese government is taking various measures.

Meanwhile, the Japanese government is targeting the growth of tourism in Japan, and has positioned the tourism industry as a key policy [1]. Kyoto in particular has become a global tourist destination city, receiving 50 million visitors annually (130,000 per day) [2]. With the trend for increasing overseas tourists, a dramatic

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increase is anticipated particularly among tourists from economically prospering Asian nations. It can be assumed that large numbers of tourists will be affected if an earthquake or other disaster occurs in such a tourist destination city. However, the disaster prevention countermeasures currently conducted by the government target local residents, and measures that apply to tourists and other irregular visitors from other regions, who are unfamiliar with the area, have only just begun in recent years. For tourist destination cities, the safety of tourists is a factor that cannot be ignored, and it can be stated that protection of their safety is the responsibility of the national and regional authorities.

During a large-scale disaster, it may be problematic for irregular visitors such as tourists and business trippers to return home, as public transport may be stopped or roads may be closed due to damage to roads and railroads and control of traffic. When huge numbers of people are stranded and unable to return home, there is a risk of secondary disaster occurring as large crowds inundate the main transport terminal in the hope of obtaining information about evacuation, moving to a safe place, and returning home. In order to prevent such a secondary disaster, attempts have been initiated to reduce the concentration of stranded persons by guiding them to temporary evacuation shelters dispersed around the city at locations such as parks. In Kyoto, a disaster response guidance method is being examined for the safe evacuation of tourists in sightseeing areas scattered over a wide area, in which tourists who attempt to converge on the central area from peripheral sightseeing areas are provisionally detained in a temporary evacuation shelter. It is important for evacuees to know about evacuation behavior and the locations of temporary evacuation shelters they should move to during a disaster, and also to correctly follow these procedures, in order for the effectiveness of such measures to be demonstrated.

Accordingly, in this study we propose a system that provides disaster information and accurate information about evacuation behavior, for which tourists are the main target. One aim of this system is to provide tourists from within Japan and from overseas with information about the disaster, public transport including status of rail transport, etc., and information on evacuation areas. Specifically, we aim to develop an interface that allows the user to ascertain the situation visually, as far as possible without relying on language. Another aim of this system is to guide evacuees away from transport hubs and towards temporary evacuation shelters such as disaster prevention broadcast bases. Since the temporary evacuation shelters are dispersed around the city, it is necessary to conduct guidance safely, and with a method in which the evacuee can follow instructions, in response to the evacuee's location. In order to conduct guidance that is adapted to location, in this study we focus on bus stops, which are installed in many cities at approximately regular intervals, and provide information related to evacuation guidance at each bus stop. Furthermore, we also propose a method to determine which evacuation shelter to move to from each bus stop, in order to provide guidance instructions that are not only safe but also can obtain the evacuee's trust.

Using this information provision system, we aim to support the initial responses of relevant persons on-site at the regional center, and also to prevent occurrence of secondary disaster and chaos caused by concentration of evacuees at the main station terminal, by providing information that contributes to the smooth evacuation guidance of tourists and other visitors.

2 Related Work

2.1 Behavioral Analysis of Stranded Persons in the Tohoku Earthquake

Although the Tohoku Earthquake, which struck on March 11, 2011, principally damaged the Tohoku region, public transport in the Tokyo metropolitan area was also severely affected, and many people became stranded and unable to return home. Behavioral analysis of victims during the 2011 Tohoku Earthquake, focusing on the Tokyo metropolitan area, is reported in [3]. Among stranded persons who walked home, around 43% visited another location before they reached their homes; the most commonly visited location was "a rail station, or station area" at 30.3%, followed by "a convenience store".

A considerable number of the stranded persons attempted to obtain information by visiting such a location. In this study, by transmitting evacuation-related information at bus stops that exist at walkable distance intervals, we aim to transmit information directed at visiting stranded persons.

2.2 Tourist Evacuation Guidance Method Evaluation Support System

An information sharing support system using WebGIS proposed by Aoyama et al. of Kogakuin University is a communication tool that targets sightseeing areas, utilizing electronic maps accessible via the Web (GIS: Geographic Information System) [4]. Outside of disaster occurrence, businesses engaged in the tourism industry can use the system to provide tourism PR information, and during disasters, each of these businesses becomes a disaster shelter for tourists and local residents and transmits information. A wide range of system users is assumed, including residents, municipal government staff, tourists and tourism-related businesses, and a key feature of the system is the potential for users to mutually convey information, whether during a disaster or in normal periods.

We will explain the system process for normal periods and during disaster occurrence, respectively. Firstly, during normal periods, the system provides information related to tourism and disaster prevention. As each business can update their own tourism information and special recommendations, it is possible for the system to maintain up-to-date information. The process of registering information updates is as follows: 1) the registrant (business, resident, etc.) selects a category icon for information related either to tourism or to disaster prevention, 2) confirms the registered location, 3) inputs detailed information. With this process, the registration operation is simplified, and it is possible for anyone to register information. Moreover, the system is also assumed to aim to have a synergistic effect on tourism PR, as the registered information can be applied as a communication tool for information-sharing between residents, municipal government staff, tourists and tourism-related businesses, etc., via the Internet.

Next, during the occurrence of a disaster, it becomes possible to aggregate information from numerous businesses dispersed over the city, such as their respective business continuation status, readiness for accepting disaster victims, the conditions of the local vicinity, and so on. By handling information appropriate for the situation,

the system is envisaged to play a large role in ascertaining the local damage situation during the occurrence of a disaster.

This system has been further expanded into a system for the contribution and sharing of disaster prevention information via cooperation between residents and municipal government [4]. When the user inputs location information with disaster or damage information, a pictogram that expresses the disaster/damage status (complete destruction, partial destruction, partial collapse, fire outbreak, etc.) is displayed on the system screen in the relevant location. The advantage of the system can been found in the fact that it is possible to comprehend the information contents at a glance.

3 System Construction

In this study, we propose a system that targets tourists who are unfamiliar with the area during disaster occurrence, provides an interface that allows the user to visually perceive information about the disaster, public transport, etc., and indicates evacuation behavior in response to the tourist' location.

We envisage smartphones to be used as a device to provide this information, as their adoption has expanded, and there is a high possibility that they are carried by tourists around sightseeing areas. However, immediately after the 2011 Tohoku Earthquake, telephone and email services for cellphones were temporarily suspended due to over-congested lines caused by cellphone companies' restriction of communications. In contrast, in the case of smartphone users, it was reported that earthquake victims were able to use WiFi services and confirm their personal safety on social media. Currently, provision of WiFi spots is increasing in places visited by large numbers of people, such as shopping districts and station areas in major cities, and anyone who completes a simple registration procedure can use WiFi wireless networks in such places. For example, WiFi networks have been set up at bus stops located at various locations in the city of Kyoto, and visiting tourists are being encouraged to use them.

Accordingly, in this study, we provide useful information at bus stops that is appropriate for the area and support for evacuation guidance, on the premise that tourist evacuees will use WiFi networks at bus stops during the occurrence of a disaster. In concrete terms, the system will provide the follow information.

1. Disaster information: Disaster information for the surrounding areas, centering on the access points used by tourist evacuees, as well as information on facilities useful for evacuation, will be displayed on a map in the form of pictograms. Our reason for using pictograms is so that tourists whose native language is not Japanese will be able to easily comprehend the situation from the pictogram images. The system allows users to select the categories of displayed information, thus avoiding overcrowding of the map screen with multiple pictograms, and heightening cognition.
2. Evacuation guidance: In order to conduct smooth evacuation guidance for a huge number of evacuees, it is necessary that evacuees do not head immediately to the main transport terminal, but first evacuate to temporary shelters, and then perform a phased evacuation in accordance with the support of the authorities. Thus,

the system's evacuation guidance provides clear instructions about which temporary evacuation shelter users should go to from each bus stop location.

4 System Proposal

We aim to develop a map-based system whereby tourists can obtain useful information from WiFi access points, as a Web application that can be used by both the iOS and Android operating systems.

The system contents for the provision of disaster information and evacuation guidance are explained respectively below.

Disaster information is displayed using pictograms on GIS. First, a selection list of information assumed to be necessary immediately after the occurrence of a disaster is displayed (Fig.1). We set five categories of information that can be selected in this system: temporary evacuation shelters, public toilets, WiFi accessible spots, convenience stores, and transport information. When the user ticks the box next to their required information category, a pictogram of the selected information only is displayed on GIS (Fig. 2). The information of these pictograms is pre-registered in a database, but when a disaster occurs, the system also provides a function whereby the system administrator can omit display of data about areas that have become unusable due to the effects of the disaster.

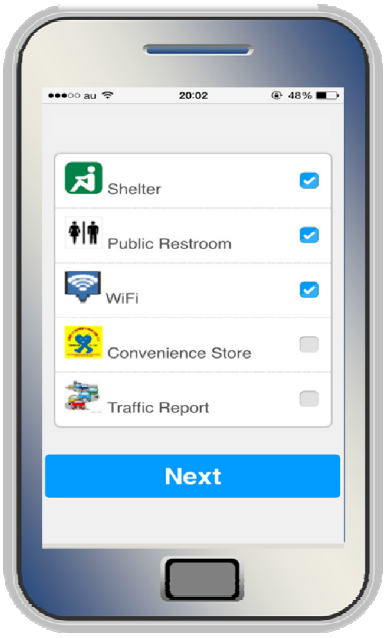

Fig. 1. List of provided information

Fig. 2. Example of evacuation guidance

The evacuation guidance function is explained as follows. It is necessary to safely guide the stranded persons who are located at each bus stop to respective temporary evacuation shelters. We specify one evacuation shelter for each bus stop, because confusion would be caused if several stranded persons at the same bus stop had different respective evacuation destinations. On the evacuation guidance screen, an appropriate evacuation route from the WiFi access point at the bus stop to the temporary evacuation shelter is displayed to the evacuees.

The location of each bus stop, the estimated number of stranded persons at each bus stop, the location of each evacuation shelter and the number of people who can be accommodated at each shelter are assumed to be known. Furthermore, with the existence of bus routes, we assume that the starting or ending point of many bus routes will be the main rail station. We propose an allocation method that takes the following points into consideration in order to safely lead stranded persons away from the main station to temporary evacuation shelters.

- The total estimated number of stranded persons at bus stops allocated to each evacuation shelter must not exceed the capacity of the evacuation shelter
- Lead the evacuees to an evacuation shelter close to the bus stop
- Evacuees from one bus stop must not overtake evacuees from another bus stop
- Where possible, guide evacuees in a direction towards the station

The allocation method is described in concrete terms below. Evacuation shelters are determined in sequence from the starting point bus stop (rail station) onwards. The system recommends evacuation shelters that are located within a circular area 50m in radius, with each bus stop at the center (Fig. 3). If an evacuation shelter with sufficient capacity for the estimated number of stranded persons at the bus stop does not

exist within the circular area, the radius of the circle is widened to 100m, then to 150m. If multiple evacuation shelters with sufficient capacity exist within the circular area, the shelter with the smallest angle in a triangle consisting of the rail station, the bus stop, and the evacuation shelter is selected (Fig. 3). When an evacuation shelter is allocated to a bus stop, the estimated number of stranded persons at the bus stop is subtracted from that shelter's capacity. This method is applied to all bus stops.

Fig. 3. Evacuation shelter recommendation method

5 Conclusion

In this paper, we proposed system construction for an information provision tool and a system that efficiently guides the evacuation of stranded persons, focusing on bus stops, in order to contribute to smooth evacuation guidance of tourists and other persons who are unfamiliar with the area during disaster occurrence.

In future, in cases when the system is unable to recommended an evacuation shelter because the nearest shelter to the station from the bus stop does not have sufficient capacity, we aim to adopt a persuasive interface and construct an effective evacuation guidance system that incorporates the current proposed algorithm.

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